

THE ACTION OF DDT ON THE GOLGI BODIES IN INSECTS NERVOUS TISSUE

BY

PEH-I CHANG

B.S., National Central University, China, 1941
M.S., University of Illinois, 1946

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THE ACTION OF DDT ON THE GOLGI BODIES IN INSECTS NERVOUS TISSUE

The insecticide 2,2 bis-(parachlorophenyl)-1,1,1 trichloroethane which is commonly known as DDT (dichlorodiphenyltrichloroethane) has proved to be one of the best insecticides ever discovered. Since the war, hundreds of published papers have given us the properties of DDT, such as its chemistry, its toxicity, its manufacture, as well as its application. But we still do not know exactly how and why DDT kills insects. However, we do know for sure that DDT is a nerve poison which affects some parts of insect nervous tissue. Many workers have done histological studies on DDT treated insects. So far, in as much as the author is aware, no one has studied extensively the internal changes of insect nerve cells that have been treated with DDT. There are, besides others, three constituents in an insect nerve cell, namely, the Golgi bodies, mitochondria, and Nissl bodies. Anything which causes a change in these three structures could affect the functioning of the whole nervous system. Therefore, the author believed that it would be worth while to study the action of DDT on these structures to find a way which may help solve the problem of the mode of action of DDT.

The author chose the Golgi body as an initial study. The Golgi body was discovered by Golgi in the year 1898. It usually appears as a group of fibrils or granules lying at one side of the nucleus or entirely surrounding it. The function of the Golgi body is still doubtful. Most investigators agree that the Golgi body is involved in the production of secretion. However, others believe that the Golgi bodies play a significant role in cellular oxidation and reduction, syntheses and hydrolyses, condensations, catalyses, electrical polarization, and other vital phenomena.

The author used American cockroaches, *Periplanta americana* (L.), and honeybees, *Apis mellifera* (L.), for his experiment. The cockroaches are primitive insects, while the honey-

bees are highly specialized insects.

The gamma isomer of BHC (benzene hexachloride), or 1,2,3,4,5,6-hexachlorocyclohexane, is not known to be a nerve poison and is extremely toxic to insects. The author has used it as a check treatment in comparison with DDT to show the significance of the result.

The mode of action of DDT is still an unsolved problem. However, we do know that DDT affects the nervous system, as well as the metabolism, and the physiological mechanism of the insects. It seems to be established that the gamma BHC interferes with the metabolism of poisoned insects and animals.

The main structure of the central nervous system of American cockroach consists, chiefly, of a brain, a suboesophageal ganglion, followed by three thoracic ganglia and eight abdominal ganglia. The brain and the ganglia are connected together with two longitudinal nerve trunks. In honeybee, there are seven ganglia in thorax and abdomen. The first thoracic ganglion is in the prothorax and is situated above the sternal furca. The last two thoracic ganglia are combined with the first abdominal ganglion to form a very large ganglion which lies beneath the arch of the combined furcae of the mesothorax and the metathorax. In the abdomen of the honeybee, there are five small ganglia.

The outermost layer of the body ganglion of the cockroach or honeybee is a nucleated sheath, the neurilemma. The principal cellular elements are peripherally located within the neurilemma, mostly in the lateral and dorsal parts. The Golgi bodies in these cellular elements were used for study in this paper. The central and ventral parts of the ganglion are occupied by a neuropile mass.

The last instar nymph of the American cockroach and the young adult of the worker honeybee served as the chief material for this study. The thoracic ganglia of the cockroach and the honeybee, and the last abdominal ganglion of the cockroach were used for preparation.

For this experiment, the author followed Da Fano's cobalt silver nitrate method. In the normal preparation, the ganglia of cockroach and honeybee were dissected out for fixing in:

Cobalt nitrate	1 g.
Distilled water	100 c.c.
Formalin	15 c.c.

In the DDT treatment, the honeybees were killed by contact action, while the cockroaches were killed by injection of 56.3 micrograms of DDT (6% acetone solution) into the abdomen of each cockroach with a syringe operated by a micrometer. In the BHC treatment, both cockroaches and honeybees were killed by contact with BHC.

The treated insects were divided into three groups, namely, knockdown, morbid, and dead. For each group, the ganglia were dissected out for fixing. The proper fixing time for both normal and treated cockroaches is four hours and for honeybees is two hours and twenty minutes.

After the material is fixed, then it is washed briefly with distilled water, and is impregnated with an aqueous solution of silver nitrate in total darkness for 24-48 hours. The strength of silver nitrate is 0.75-1% for honeybee, and 1-1.5% for cockroach.

When impregnation is completed, the material should be washed twice with distilled water and should be put into Cajal's reducing agent for 12-24 hours. Cajal's agent is composed of:

Hydroquinone	1-2 g.
Formalin	5-10 c.c.
Distilled water	100 c.c.

This solution should be freshly prepared.

The next step is to dehydrate the material in 30%, 50%, 70%, 80%, 95%, and 100% ethyl alcohol for one to two hours in each solution, and to clear it with cedarwood oil overnight.

The cleared material is then infiltrated with 56-58° paraffin

for at least six hours. Then it is imbedded, sectioned (6 microns), and affixed on slides with albumen.

For staining, run the slides from xylol, absolute alcohol . . . down to distilled water, then stain the slides with 0.1% gold chloride for one and one half hours and counterstain with alum carmine for half an hour or less. After dehydration and clearing, the material is mounted on slides in Canadian balsam for observation.

In normal specimens, the Golgi bodies, dispersed between the nucleus and the cell wall are numerous coarse, granular structures with various shapes, such as kidney, egg, pear, short filament, and many other irregular shapes. However, most of them are more or less rounded. They are well developed in active stages of differentiation and become less and less conspicuous as the cell ages.

Many investigators have proved that the Golgi bodies may break up or fragmentate in the nerve cell in pathological conditions. The author has reached the same conclusion. In DDT treated specimens, the Golgi bodies begin to break up prominently in the knockdown stage; then the Golgi bodies break up more and more and even vanish as the insects become morbid and die. In the BHC treated specimens, the Golgi bodies undergo the same course of breaking up, except they remain fairly normal in the knockdown stage, and can still be identified in the dead stage. These facts tend to show that DDT has a tendency to speed up the breakage of the Golgi bodies in the nerve cell of the insects, while BHC has no such effect.

VITA

Peh-I Chang was born October 10, 1917, at Changteh, Hunan, China. His first ten years were spent with his parents on a farm near the village of Lao-Duh-Kow where he completed his grammar school education. In 1927, he entered the Changteh Junior High School; from there he went to Changsha to finish high school. In 1937, he was admitted to the National Central University at Nanking, but the war between China and Japan prevented his going to Nanking to study. He went to Chungking, the University having been moved there during the war, where he studied under fierce bombardment from Japanese planes for four years and finally received his B.S. degree in July, 1941. After graduation from the National Central University, he immediately accepted a position from the National Central Agricultural Research Bureau as an assistant technologist in charge of the research work concerning the control of tung oil tree insects. In 1944, he served as an instructor in the Agronomy Department of the National Fu-Tang University, where he

taught Horticultural Entomology and was in charge of the laboratory work of General Entomology. In the fall, he passed an examination, sponsored by the Chinese Government, for students going overseas. In November, 1944, he flew from Chungking to Calcutta, India, and took a ship to the United States. He entered the University of Illinois in 1945 and received his M.S. from the same institution in the Entomology Department in 1946. He continued his entomological training on a fellowship offered by the Graduate College of the University of Illinois from 1946 to 1949. He was married in 1948.

During his four years of study at the University of Illinois, he was elected a member of the honorary societies of Phi Kappa Phi, Sigma Xi, and Phi Sigma.

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